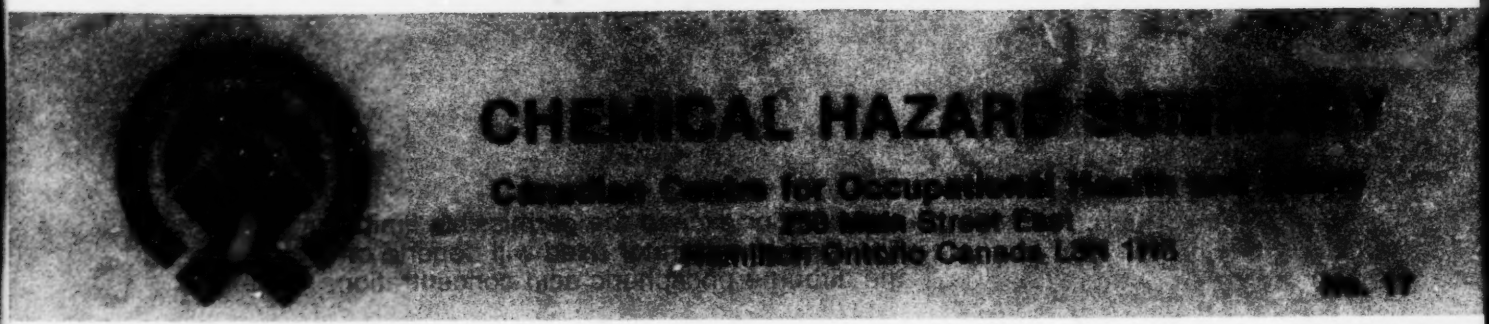

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PHOSPHORIC ACID

Other Names	Orthophosphoric acid, H_3PO_4, CAS 7665-38-2
Description	The most common commercial forms of phosphoric acid are solutions of 75 to 85% acid dissolved in water. These solutions are clear, odourless, syrupy liquids. Pure (100%) phosphoric acid, which is not available commercially, is a solid at room temperature.

HAZARD SUMMARY

Exposure	Mist: Inhalation, skin contact and eye contact. Liquid: Skin contact, eye contact, ingestion.
Effects of Short-Term Exposure	Phosphoric acid is corrosive. It can cause severe burns to skin and eyes. Splashes in the eyes may result in permanent damage. Inhalation of acid mist may cause irritation of nose and throat.
Effects of Long-Term Exposure	Inflammation of the skin (dermatitis) may occur from repeated or prolonged skin contact with dilute solutions.
Fire and Explosion Hazards	Phosphoric acid is not flammable, but flammable hydrogen gas is produced by reaction of this material with many metals.
Fire Extinguishers	Water spray may be used to cool containers involved in a fire and also to reduce vapours and mist.
Personal Protection	Protective clothing such as gloves, coveralls and boots made of butyl rubber, neoprene, nitrile rubber or polyvinyl chloride (PVC) is recommended. Splash-proof chemical safety goggles and a face shield (eight inch minimum) should be worn for eye and face protection. Appropriate respiratory protection should be worn whenever mist concentrations

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	approach or exceed the permissible limit. The type of respirator used will depend on the airborne phosphoric acid concentration.
Chemical Reactivity	Phosphoric acid reacts violently with caustics (e.g. sodium hydroxide). It should not be mixed with sulphides, phosphides, acetylides, cyanides, fluorides, carbides, silicides, or strong oxidizing agents.
Storage	Phosphoric acid solutions may be stored in glass or other acid-resistant containers.
Exposure Limits	As recommended by the American Conference of Governmental Industrial Hygienists (ACGIH) 1985-86. Time-Weighted Average Exposure (TWA): 1 mg/m^3 (milligrams per cubic metre) Short-Term Exposure Limit (STEL): 3 mg/m^3

TWA is defined as the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek.

STEL is defined as a 15-minute time-weighted average exposure which should not be exceeded at any time during a workday. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL.

SCOPE OF THE DOCUMENT

This summary was prepared at the Canadian Centre for Occupational Health and Safety (CCOHS) and is intended primarily as a source of information for persons who work with or may be occupationally exposed to this material. The information selected for inclusion is believed to be reliable and generally relevant to occupational health. Other information which bears on particular work situations may be available. The scientific data in many areas are limited and may allow a variety of interpretations. Additional information, corrections, comments, and questions are welcome, and should be addressed to the Inquiries Service, CCOHS, 250 Main Street East, Hamilton, Ontario, L8N 1H6, (416) 572-2981.

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I. USES AND OCCURRENCE

Several chemical forms of phosphoric acid are available commercially. The most widely used form of this acid, the material commonly known as "phosphoric acid," is orthophosphoric acid (H_3PO_4). Phosphoric acid is usually sold in concentrations of 75, 80 and 85%, although products ranging from 33 to 115% are available[1].

Other chemical forms of phosphoric acid are metaphosphoric acid, pyrophosphoric acid, super-phosphoric acid, polyphosphoric acid, and anhydrous phosphoric acid (also known as phosphorus pentoxide). These forms have different properties from orthophosphoric acid, but share many of the same hazards.

This document deals mainly with orthophosphoric acid since it is the most widely used form of phosphoric acid.

Phosphoric acid is used as a fertilizer and food additive. It is also used in the manufacture of fertilizers, phosphate salts, polyphosphates, detergents, activated carbon, animal feed, ceramics, pharmaceuticals, food products, rust inhibitors, wax and rubber latex.

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In addition, phosphoric acid is used for electropolishing, engraving and photoengraving, printing, metal cleaning, sugar refining, and water-treatment.

II. TOXICOLOGY

Routes of Exposure
Inhalation of mist, and skin and eye contact are the main routes of exposure.

Effects of Short-Term Exposures in Humans

Inhalation
The potential health hazards of this material are primarily due to its corrosive nature. There is no evidence that phosphorus poisoning results from exposure to phosphoric acid. The effects of exposure to phosphoric acid depend mainly on the concentration of phosphoric acid and the duration of exposure.

Phosphoric acid does not form vapours easily at room temperature. Therefore, exposure to high concentrations of phosphoric acid vapour is unlikely to occur. However, phosphoric acid mist may be generated in certain operations. Exposure to the mist may cause irritation of the nose and throat.

Very little information is available on the health effects of inhaled phosphoric acid. The following toxic effects have been reported in humans exposed to phosphoric acid or phosphorus pentoxide dust (anhydrous phosphoric acid) for brief periods[2,3].

0.8 to 5.4 mg/m^3	Mild discomfort.
3.6 to 11.3 mg/m^3 (phosphorus pentoxide)	Exposure caused coughing among unaccustomed workers but was tolerable.
100 mg/m^3 (phosphorous pentoxide)	Exposure was intolerable except to accustomed workers.

Note: phosphorus pentoxide is converted to phosphoric acid when in contact with moisture such as in humid air, on the skin or in the nose and throat.

Inhalation of phosphoric acid mist or vapour is unlikely to cause severe lung damage. However, extremely toxic phosphine gas can be

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formed when certain steels are pickled with phosphoric acid at high temperatures. There have been two reports of workers being overexposed to phosphine gas when a phosphoric acid pickling bath, heated to 170°F, was used to remove rust from steel.

In both cases, it was believed that the high temperature of the bath and/or the acid concentration produced enough free hydrogen to react with the phosphoric acid or alternatively with the small phosphorus content of the steel to produce the phosphine gas[4,5].

Effects on the Eyes

Exposure to phosphoric acid mists may cause eye irritation.

With splashes of phosphoric acid solutions, the severity of the injury varies according to the quantity, concentration and duration of contact. In one case, a weak solution caused moderate brief irritation, but no injury[6]. Concentrated solutions of phosphoric acid can cause severe burns which may result in permanent eye damage.

Effects on the Skin

The severity of the injury to the skin varies according to the area of skin affected, the concentration of the solution and duration of contact. Phosphoric acid solutions can cause irritation or corrosion of the skin.

If not rinsed off quickly with water, concentrated solutions of phosphoric acid can cause severe burns.

Ingestion

Swallowing phosphoric acid is unlikely to occur in the workplace. When concentrated solutions are swallowed, burns to the mouth and the digestive tract occur. There is pain in the stomach, difficulty in breathing, nausea, vomiting, diarrhea, convulsions, and in severe cases, collapse and death[1].

Effects of Long-Term (Chronic) Exposure

There are no reports of chronic poisoning from absorption of phosphoric acid. Dermatitis may occur from repeated or prolonged skin contact.

Toxicity Data in Animals

The poisoning potential of a compound relative to other chemicals can be assessed from the LD_{50} (lethal dose) values obtained in animal tests. The LD_{50} is the amount of a chemical (weight of chemical/weight of animal) which is needed to kill one-half (50%) of

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the test animals. Test animals are usually rats, mice, or other rodents. Routes of exposure are usually oral (by mouth), dermal (absorption through the skin), or inhalation (breathing of vapour). Listed below are the LD_{50} values for this material:

LD_{50} (rat, oral)	1,530 mg/kg
LD_{50} (rabbit, dermal)	2,740 mg/kg

III. FIRE AND EXPLOSION HAZARDS

Phosphoric acid is non-flammable and non-combustible. However, in contact with many common metals such as iron or zinc, explosive and flammable hydrogen gas is produced.

Fire Extinguishing Agents
Water may be used for fires in which phosphoric acid is involved. Water spray may also be used to keep fire-exposed containers cool and to knock down acid vapours and mist[7].

Chemical Reactivity
Phosphoric acid can react violently with bases such as caustic soda. Reaction with sulphides, phosphides, cyanides, acetylides, fluorides, silicides, and carbides releases flammable and/or poisonous gases. Potentially dangerous reactions can also occur with strong oxidizing and reducing agents and certain laboratory chemicals[1].

IV. EXPOSURE CONTROL

In many operations where phosphoric acid is used, general (dilution) ventilation may be adequate. If phosphoric acid is heated or a mist is generated, local exhaust ventilation and other engineering controls may be necessary. The contaminated air should be exhausted directly to the outside. Corrosion-resistant equipment should be used.

Although engineering controls such as ventilation are the preferred methods of controlling exposure to contaminants in the workplace, the use of personal protective equipment (such as special clothing and respirators) may increase the level of protection for workers exposed to this material. In some situations, such as working in enclosed spaces and in some maintenance operations, the use of personal protective equipment may be essential since effective ventilation and engineering controls may not be possible. Eye-wash fountains and safety shower facilities should be provided for emergencies.

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Protective Clothing
Protective clothing such as gloves, coveralls, aprons and overshoes should be worn when handling phosphoric acid solutions above 1.6%[8]. Protective clothing should also be worn to prevent repeated or prolonged contact with weak acid solutions (below 1.6%).

Chemical protective clothing made of butyl rubber, neoprene, nitrile rubber or polyvinyl chloride (PVC) is recommended[9].

Splash-proof chemical safety goggles and a face shield (eight-inch minimum) should be worn when handling acid solutions greater than 1.6%. For weak solutions (less than 1.6%), splash-proof chemical safety goggles may be adequate.

Respiratory Protection
Factors to be considered when implementing a respiratory protection program include:

- Selection of appropriate respirators
- Respirator fit
- Respirator maintenance
- Cartridge life
- Worker training.

These factors are described in more detail in CSA Standard Z94.4, "Selection, Care, and Use of Respirators", available from the Canadian Standards Association.

The degree of respiratory protection required depends on the concentration of the vapour and the duration of the exposure. The National Institute for Occupational Safety and Health (NIOSH)[3] recommends the following respiratory protection:

- MIST CONCENTRATION UP TO 25 mg/m^3:
  Any supplied-air respirator operated in a continuous flow mode.*

- MIST CONCENTRATION UP TO 50 mg/m^3:
  Any supplied-air respirator with a full facepiece; or
  Any self-contained breathing apparatus with a full facepiece; or
  Any air-purifying full facepiece respirator with a high-efficiency particulate filter.

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- MIST CONCENTRATION UP TO 2,000 mg/m^3:
  Any supplied-air respirator with a full facepiece and operated in a pressure-demand or other positive pressure mode.

- EMERGENCY OR PLANNED ENTRY IN UNKNOWN CONCENTRATIONS OR IMMEDIATELY DANGEROUS TO LIFE OR HEALTH (IDLH)** CONDITIONS:
  Any self-contained breathing apparatus with full facepiece operated in a pressure demand or other positive pressure mode; or
  Any supplied-air respirator with a full facepiece and operated in pressure-demand or other positive pressure mode in combination with an auxiliary self-contained breathing apparatus operated in pressure-demand or other positive pressure mode.

- ESCAPE:
  Any air-purifying full facepiece respirator (gas mask) with a chin-style or front- or back-mounted canister providing protection against phosphoric acid and having a high-efficiency particulate filter; or
  Any appropriate escape-type self-contained breathing apparatus.

*Eye protection such as chemical safety goggles may be required.

**IDLH level is defined, for the purpose of respirator selection, as the maximum concentration from which one could escape within 30 minutes without any escape-impairing symptoms or any irreversible health effects.

Note: The above recommendations apply only to equipment approved by NIOSH or the Mine Safety and Health Administration (MSHA).

V. SMALL-SCALE STORAGE AND HANDLING

Phosphoric acid solutions should be stored in glass containers or other acid-resistant materials. Protect containers from damage or breakage and store away from incompatible materials. The storage area should be clean and well ventilated. It should have acid-resistant flooring and approved drainage. Use corrosion-resistant equipment and surfaces in areas where hot or misted phosphoric acid is present[1]. Keep soda ash or lime nearby for emergency use.

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To prevent crystallization of concentrated phosphoric acid solutions, minimum storage temperatures are 21 deg C for 85% solutions, 4 deg C for 80% solutions, and -18 deg C for 75% solutions.

When preparing or diluting acid solutions, add the acid slowly to water with plenty of careful stirring. This will prevent splashing and splattering of the acid.

Clean-up

Protective clothing such as chemical splash goggles, face shield (eight inch minimum) and boots should be worn for the clean-up operation. All persons participating in the clean-up must be appropriately trained. Others should be restricted from the spill or leak area until clean-up has been completed. The area should be well ventilated. All ignition sources and incompatible materials should be removed from the area, and smoking should be prohibited. The appropriate environmental authorities should be notified in the event of a release of phosphoric acid into the environment.

Stop the leak at the source if it can be done safely.

Small spills of phosphoric acid solutions may be neutralized cautiously with sodium bicarbonate ($NaHCO_3$) or a mixture of soda ash/slaked lime. The residue can then be shoveled into containers for disposal.

For large spills, the liquid may be recovered if it can be done safely. Place the liquid in appropriate covered, labelled containers. The solution remaining after recovery or the entire spill may be cautiously neutralized with lime (CaO) or soda ash (Na_2CO_3).

Lime is the preferred neutralizing agent because of the low solubility of the calcium phosphate formed[1]. The residue (calcium phosphate) can then be shovelled into containers for disposal or for use as fertilizer.

Disposal

Federal, territorial, provincial and local regulations should be reviewed prior to disposal of waste phosphoric acid.

Untreated waste phosphoric acid or acid contaminated water must never be discharged directly into sewers or surface waters. Following neutralization either at the spill site or at a waste management facility, the residue can be disposed of in a secure landfill. Phosphoric acid neutralized with lime can be used as a fertilizer[1].

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VI. FIRST AID

The following general procedures are suggested for first aid involving poisoning by phosphoric acid:

Inhalation
Remove the source of phosphoric acid or move the victim to an uncontaminated area. Obtain medical attention immediately.

Eye Contact
If irritation occurs due to exposure to mist, or if the liquid is splashed into the eye, immediately flush the affected eye(s) for *at least* 30 minutes, by the clock, with lukewarm, gently flowing water, with the upper and lower eyelid(s) held apart. Obtain medical attention immediately.

Skin Contact
If a phosphoric acid solution is splashed on the skin or if the mist irritates the skin, the affected area should be flushed with lukewarm, gently running water for *at least* 20 minutes by the clock. The eyes and uncontaminated skin should be protected from contamination. Contaminated clothing, shoes and leather goods such as watchbands should be removed under running water. These items should be thoroughly washed and decontaminated before re-use. Medical attention should be obtained immediately.

Ingestion
Never give anything by mouth if the victim is rapidly losing consciousness, or is unconscious or convulsing. In all cases, rinse any residual phosphoric acid from the mouth with water. Because of the corrosive nature of this material, DO NOT INDUCE VOMITING. Have the victim drink about 250 ml (8 ounces) of water to dilute the material in the stomach. If vomiting occurs naturally, the victim should again drink 240 to 300 ml of water. Quickly transport victim to an emergency facility.

Note: Provide general supportive measures (comfort, warmth, rest). Consult a physician and/or the nearest Poison Control Centre for all cases of ingestion or eye contact and all but trivial cases of inhalation or skin contact. All first aid procedures should be periodically reviewed by a physician familiar with the material and its conditions of use in the workplace.

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VII. EXPOSURE LIMITS

In many Canadian jurisdictions, exposure limits are similar to the Threshold Limit Values (TLVs) recommended by the American Conference of Governmental Industrial Hygienists (ACGIH). For phosphoric acid the 1985-86 recommended TLVs are[2]:

1. Threshold Limit Value-Time Weighted Average (TLV-TWA) =
   1 milligram per cubic metre (mg/m^3):

   This is "—the time-weighted average concentration for a normal 8-hour workday and a 40-hour workweek, to which nearly all workers may be repeatedly exposed, day after day, without adverse effect."

2. Threshold Limit Value-Short Term Exposure Limit (TLV-STEL) =
   3 milligrams per cubic metre (mg/m^3):

   "A STEL is defined as a 15-minute time-weighted average exposure which should not be exceeded at any time during a workday even if the eight-hour time-weighted average is within the TLV. Exposures at the STEL should not be longer than 15 minutes and should not be repeated more than four times per day. There should be at least 60 minutes between successive exposures at the STEL.

   It is not a separate independent exposure limit, rather it supplements the time-weighted average (TWA) limit where there are recognized acute effects from a substance whose toxic effects are primarily of a chronic nature. STELs are recommended only where toxic effects have been reported from high short-term exposures in either humans or animals."

Certain Canadian jurisdictions have adopted the entire set of ACGIH TLVs for chemical substances by reference in their regulations. Others use the TLVs as guidelines for control of airborne contaminants. Still others specify exposure limits for chemical substances, including phosphoric acid, in their regulations. Since the manner in which exposure limits are established, interpreted and implemented can vary among the jurisdictions, detailed information should be sought from the appropriate government agency in each jurisdiction.

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According to the preface in the ACGIH booklet[2]:

"Threshold limit values refer to airborne concentrations of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. Because of wide variation in individual susceptibility, however, a small percentage of workers may experience discomfort from some substances at concentrations at or below the threshold limit; a smaller percentage may be affected more seriously by aggravation of a pre-existing condition or by development of an occupational illness.

Threshold limits are based on the best available information from industrial experience, from experimental human and animal studies and, when possible, from a combination of the three.

The TLV-TWA should be used as guides in the control of health hazards and should not be used as fine lines between safe and dangerous concentrations." (Reproduced by permission of the ACGIH).

Warning Properties of Phosphoric Acid at the Exposure Limit

For certain substances, odour or irritant properties may be useful as short-term indicators of possibly hazardous conditions. Phosphoric acid is an odourless compound. It may be detected due to its irritating properties at concentrations of 0.8 to 5.4 mg/m^3. However, because the irritation level of phosphoric acid is near or above the TLV-TWA of 1 mg/m^3, it is considered to be a material with poor warning properties.

Exposure Limits in Other Nations

The approaches or mechanisms for establishing and applying occupational exposure limits can vary widely from country to country. Information on exposure limits in a number of foreign jurisdictions is available from CCOHS.

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VIII. CHEMICAL AND PHYSICAL PROPERTIES

CAS Registry Number	7665-38-2
Chemical formula	H_3O_4P
Chemical structure	$O=P(OH)_3$

Physical Properties[11] (85% H_3PO_4)

Freezing point	21 deg C (70 deg F)
Boiling point	158 deg C (316 deg F)
Density	1.689 g/ml at 20 deg C
Solubility in water	Completely soluble
Vapour pressure	0.29 kPa (2.18 mm Hg) at 20 deg C
Odour threshold	Odourless
pH	1.5 (1.0% H_3PO_4 at 20 deg C)

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Note: Additional references on this subject are available from CCOHS upon request.

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